Solving a Nonlinear Equation - Mechanical Engineering

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1 Problem

A trunnion has to be cooled before it is shrink fitted into a steel hub.

We are given the equation to find out at which temperature we need to cool down the trunnion in order to get the desired shrinking.

$$f(T_f) = -0,50598 \cdot 10^{-10} T_f^3 + 0,38292 \cdot 10^{-}7 T_f^2 + 0,74363 \cdot 10^{-}4 T_f + 0,88318 \cdot 10^{-}2 \tag{1}$$

2 Solution

To solve the problem we have to find a solution to equation 1. In order to do this, we can do it by using a computer algorithm that uses one of the following methods:

- Newton's method
- Bisection method
- Secants method

The code is reported below.

```
#include "functions.hpp"
#include <iostream>

using namespace std;

void result(PointSearchResult res){
    cout << "A root has "<<(res.found?"":"not ")<<"been found in "<<res.iter<<" iterations: f("<<res.x<<")="<<res.y<<'\n';
}

int main(){
    double a, b;
    cin >> a >> b;
    Cubic f = Cubic(-0.50598e-10, 0.38292e-7, 0.74363e-4, 0.88318e-2);
    cout << "Newton's method: ";
    result(f.findRootNewton(a, 1e-5, 1e7));
    cout << "Bisection method: ";
    result(f.findRootBisection(a, b, 1e-5, 1e7));
    cout << "Secants method: ";
```

```
    result(f.findRootSecants(a, b,1e-5, 1e7));
}
```

trunnion.cpp

3 Discussion

Firstly, we have applied all methods with $T_{f0} \in [-130; -110]$, taking the leftmost poiint as the initial guess for Newton's method. The output follows.

```
Newton's method: A root has been found in 1 iterations: f(-128.753)=9.00726e-08
Bisection method: A root has been found in 4 iterations: f(-129.375)=-3.84176e-05
Secants method: A root has been found in 2 iterations: f(-128.755)=-2.21485e-08
```

Then, we chose this interval: $T_{f0} \in [-1 \cdot 10^3; 1 \cdot 10^3]$.

```
Newton's method: A root has been found in 3 iterations: f(-802.927)=1.8381e-06
Bisection method: A root has been found in 9 iterations: f(-126.953)=0.00011187
Secants method: A root has been found in 7 iterations: f(1688.45)=1.86587e-11
```

Then, we chose this interval: $T_{f0} \in [-5 \cdot 10^2; 1]$.

```
Newton's method: A root has been found in 10 iterations: f(-802.905)=2.46225e-09
Bisection method: A root has been found in 10 iterations: f(-128.898)=-8.86823e-06
Secants method: A root has been found in 5 iterations: f(-128.755)=-2.86784e-10
```